Appendix B

COMPUTER PROGRAMS

USDA – NRCS

MO-ENG-C109
3-00
File Code: Coop. Folder

PIPELINE DESIGN PROCEDURE

Information to collect

1) Type of Livestock _____

2) Number of Livestock _____

3) Water needed: gal / day / head: (1.5) (12) (25) (_____) **Circle one**

   Compute Minimum Flow Rate (item 2 x item 3) $\div$ (60 x 8*) = _____ gal / min

4) Grazing months: From _____ To _____

5) Type of stock tank shut off: (Manual) (Float) **Circle one**

6) Stock tank Size: _____ gal

7) Sketch possible pipeline route on plan map or USGS topographic map.

8) Utilities Present (Yes) (No) **Circle one**

9) Existing Pressure Tank: (Yes) (No) **Circle one**

   Size _____ Gal

   On Pressure _____ PSI

   Off Pressure _____ PSI

10) Other information if new well will be constructed, a new pressure tank is installed, or expansion of herd is planned.

   Pump capacity: _____ Gal / Min   Source of Information

   Other uses of the well: Landowner

   household: _____ (35-50 gal/day/person)   AWMFH

   farm: _____   Missouri Livestock Watering
                                                                            Systems Handbook
   milkhouse: _____

   other: _____   Midwest Plan Service MWPS-14

   Total Gal/Day: _____

   _____

   _____

   _____

   *8 hours used for calculation. Assumption is that cattle will place peak demand during these hours. Actual hours range between 8 and 12.

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PROCEDURE FOR DETERMINING EXISTING PUMP CAPACITY OF SYSTEM

No water should be used by the operator during this process.

1) Open any faucet and run until the pump turns "on".

2) Close the faucet and let the pump fill the pressure tank until it turns "off".

3) Open the faucet closest to the pressure tank and collect all the water discharged until the pump turns "on".

4) When the pump turns "on", close the faucet and start timing the pump cycle. (Pump "on" to pump "off")

5) Record the time for the pump cycle. _____ seconds

6) Measure the gallons collected in step 3. _____ gal

7) Average pumping capacity: (item 6 ÷ item 5) x 60 = _____ gal / min

Example:

9 gals collected in 72 seconds (1 min 12 sec)

(9 ÷ 72) x 60 = 7.5 gal / min (average)

MISSOURI LIVESTOCK WATERING SYSTEMS HANDBOOK

APPENDIX B

PROCEDURE FOR PIPELINE DESIGN

THIS PROCEDURE WAS ADAPTED FROM
WISCONSIN WITH VERY LITTLE CHANGE

The Missouri pipeline spreadsheet program can be used to design a pipeline system. Attached are design examples. Two options are available in the spreadsheet, **"Design"** and **"Pipe Q"**. The "Design" tab requires the user to input Q (gal / min), and the "Pipe Q" tab Q (gal / min) is solved for, based on the layout of the pipeline and a given pressure at the outlet.

Other design considerations

Check the pressure tank for size and cycling. The "Pressure Tank Design Procedure Example" is used.

The spreadsheet gives the pressure rating of the pipe at each station. A safety factor of 1.4 is included.

"Design" tab (example) Exhibits 1 and 2

This system will deliver 6 gal / min to the outlet at station 1200. The minimum pressure tank setting is 50 psi to push the 6 gal / min over the hill. A lesser pressure would push less gal/min over the hill.

"Pipe Q" tab (example)   Exhibits 3, 4 and 5

These three exhibits show changes that occur in the same pipeline system as the pressure at the outlet is increased. Note the rise in the hydraulic grade line of the system at the critical station of 600. Exhibit 5 shows the maximum flow rate for this system with the given pressures. Lesser pressures will have flow but are not calculated by the spreadsheet. The same results can be achieved by changing the "design" tab numbers.

"Design" tab (example) Exhibit 6 and 7

This exhibit shows outlets at different locations. Some design changes will be required to make this work.

PRESSURE TANK DESIGN PROCEDURE EXAMPLE

The Desired Outcome

Provide a pressure tank which will cause the pump to recycle not more than 6 times per hour when pumping the average rate needed to supply the maximum daily use.

What pressure tank size is needed for an average pump rate of 14 gal / min and given pressure tank settings of: 50 psi on, 70 psi off?

Max daily use:

175 beef cows at (12 gal / day / head) = 2100 gal / day

House 360 gal / day

Total use = 2100 + 360 = 2460 gal / day

Average daily rate: 2460 ÷ (10^1 x 60) = 4.1 gal / min

Given:

In one cycle inflow = outflow

6 cycle / hour = 10 min / cycle

Then one cycle (10 min) yields 41 gal. (given by 10 min. x average daily rate of 4.1 gal.)

With an average pumping rate of 14 gal. / min, one cycle will have 2.9 minutes of pumping and 7.1 minutes of rest. During this 7.1 minutes, the pump rests but water is delivered.

41 gal / 14 gal / min = 2.9 min
10 min – 2.9 min = 7.1 min

Therefore:

7.1 min x 4.1 gal / min = 29.1 gal usable storage in the pressure tank.

This needs to be increased by the efficiency of the tank at a given operating pressure range.

(See Figure 1) 50 psi on – 70 psi off gives 21.3 % efficiency

Tank size = 29.1 / .213 = 137 gal pressure tank required.

Other pressure tank sizing charts and graphs may also be used, like Midwest Plan Service Publications - 14.

Note:

Use a shorter cycle time if needed to keep pressure tank within a reasonable size and cost range. Pump supplier should be contacted on recommended size of pressure tank.

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[1]10 hours used for calculation. Assumption is that cattle will place peak demand during these hours. Actual hours range between 8 – 12.

Figure 1 — Pneumatic Pressure Tank Efficiency

Figure 1 — Pneumatic Pressure Tank Efficiency
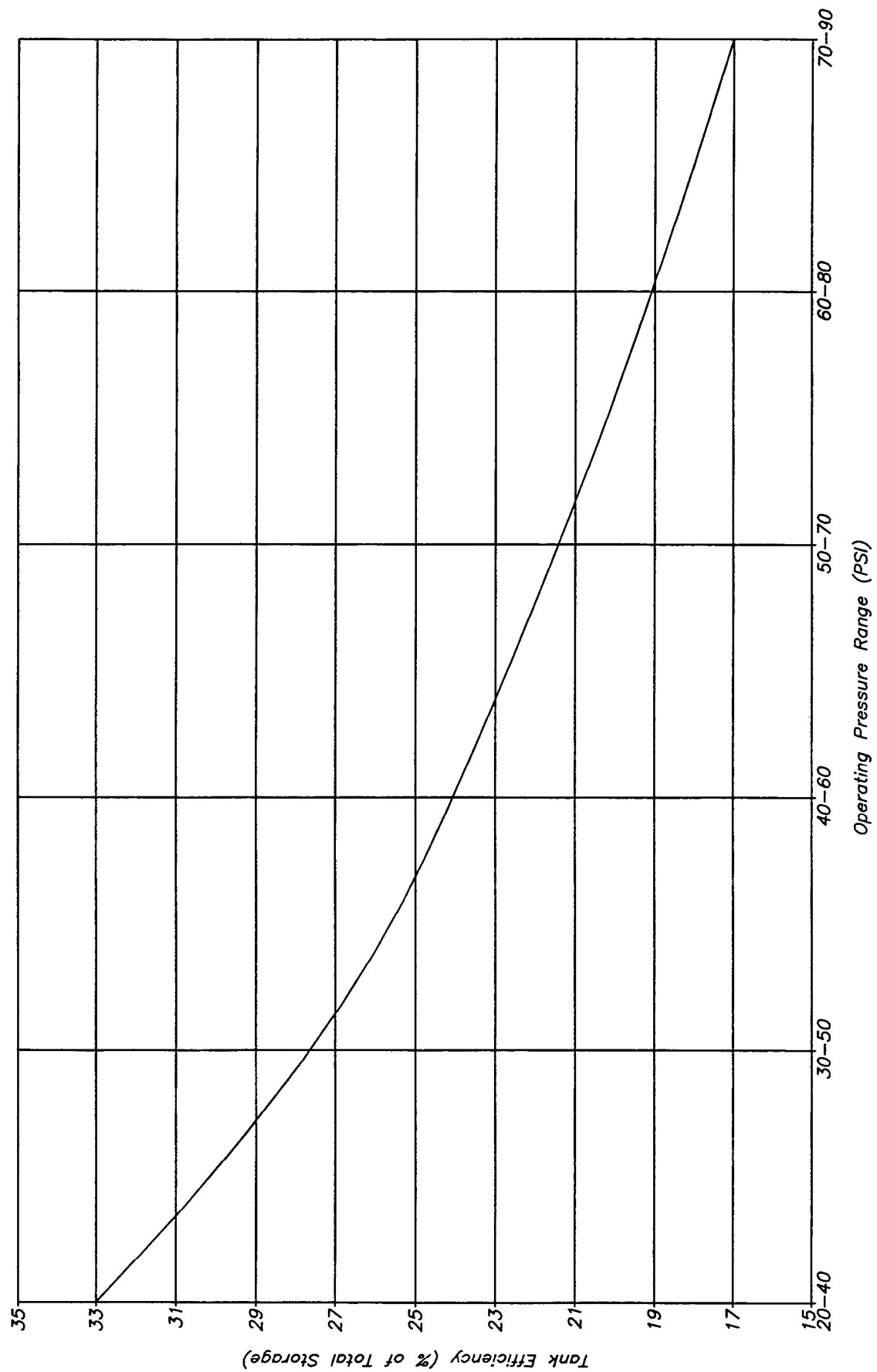
INSTRUCTIONS

These are instructions for the use of the Pipeline Spreadsheet for EXCEL. The program is designed to calculate the friction loss through a pipeline system. There is a sheet labeled "Help" that gives an explanation of terms. You need to be familiar with how to design a pipeline system before you use this spreadsheet for designing a system. There are two methods of designing a pipeline system. The tab labeled "Design" allows you to vary the flow and the pipe size throughout the system. The tab labeled "Pipe Q" solves for the flow in a system where the water is taken out at the end only and five pipe sizes can be used. The instructions for both systems are below and to the right.

INPUT (for Design tab)

The first thing that needs to be done is to clear the worksheet. There is a macro button labeled "Reset Worksheet". You need to place the cursor on this button and click on it. This will reset the worksheet. If this isn't done you may get some erroneous data.

The input to the heading section is the Client, DSN by and any Comments. Data input is the elevation of the pressure tank or water source. The high and low pressure switch settings for the pressure tank and the mannings "n" value of the pipe being used. The next item to input is the station along the pipeline. Up to 15 stations can be entered. In the outlet column you only enter a value if water is being taken out at this location, otherwise enter a zero. Typically the last station entered would have a value for the design flow in gpm. The next column is the total system flow from the pressure tank. If flow was being taken out at different stations along the pipeline, the total gpm would be reduced by the amount entered in the previous column. If you are designing for only one flow at the last station then every station would have the design flow entered. The next column to be entered is the ground elevation at each station. The next column is the pipe id. There is a sheet labeled "Pipe ID" listing the common pipes used and there corresponding pipe id. The pipe diameter entered at a station is for the length from that station to the previous station. The pipe sizes can be changed for each reach.

OUTPUT

There is a column labeled "Velocity" at the far right of the input screen. The standard specifies that if the velocity is less than 8 fps some means must be provided to remove air from the high points in the system. This column gives the velocity for each reach of the system. If you page down, the next set of columns gives the results. If there are numbers all the way across for each station entered then the design will work. If there are some columns that show "no flow" then some changes will need to be made to make the system work. Usually the flow will have to be changed or the pipe size increased. To get a visual representation of what is happening click on the sheet labeled "Graph" at the bottom of the screen. This will give a graphical representation of the ground line and hydraulic grade line. To get back to the design section click on the sheet labeled "Design". The "Help" sheet gives the explanation for each column heading. The last column gives the design pressure required at each station of the pipeline.

PRINTING

There are two macro buttons on the spreadsheet labeled "Print Design" and "Print Graph". Move the cursor to either one of these and click on it to print the desired output.

Pipe Q Tab Instructions

The Pipe Q tab is for the design of a system where there is only one outlet and up to five pipe sizes. Before starting the input data hit the "Reset Worksheet" button.

INPUT

The first input is how many pipe sizes you will be using (1-5). The next is pressure tank elevation (assumed), high and low pressure settings on the pressure tank, mannings "n" value of the pipe being used, head loss at the outlet (this is the friction loss through the control valve at the outlet) and the pipe ID. The manufacturer of the outlet valve should provide what the friction loss through; the valve for a range of flows is. If it is given in "psi" it needs to be converted to feet by multiplying it by 2.31. If you chose more than one pipe size you will be prompted for the pipe section lengths and diameters. The total of these should equal your total station length. The first pipe section is starting at the pressure tank. The profile of the pipeline is then entered using stationing starting at the pressure tank as station 0 and then entering the elevation at each station.

If you switch from one pipe size to two or more pipe sizes without resetting the worksheet you will need to erase the diameter you input for one pipe. If you go from two or more pipes to one you will need to erase the length and diameter for the sections and input the diameter in the line above.

OUTPUT

The spreadsheet will calculate the static elevation, the high and low HGL. In the upper right part of the spreadsheet, two boxes will show what the output is for the high and low pressure settings along with the velocity for each flow for each pipe diameter if more than one pipe size was used. If either HGL intersects the ground line a "No Flow" will appear in the boxes. The spreadsheet will not be able to calculate the flow for the input parameters. The input parameters will need to be changed or you will need to use the "Design" sheet if more than two pipe sizes are required. If you page down there will be a graph showing the ground profile, the high and low HGL and the static elevation. This graph will be printed when you hit the "Print Design" button.

Before starting to enter data the worksheet must be reset to work properly.

INPUTS
High and low pressure from pressure tank

Pressure tank elevation.

Mannings "n" value - This is 0.009 for PVC and Polyethylene pipe.

Station - Start stationing at pressure tank. Make sure to include lowest and highest points along the pipeline. Have a station for each outlet location.

Outlet GPM - Calculate how much water you will need per pasture. Most likely you will only be taking water out at one pasture. The outlet GPM for the other pastures will be 0. The program will handle water being removed at more than one location at a time.

Total GPM - This will be the GPM going through the system. Even though outlet GPM at a particular spigot may be 0, the total GPM will be what is required for the whole system.

Ground Elev. - This is the ground elevation corresponding to the stationing above. The lowest elevation will give the highest pressure in the pipe.

Pipe ID - This is the inside diameter of the pipe being used between the preceding station and the current station. For a given pipe size there are several inside diameters depending on pipe material and pressure rating.

OUTPUTS

Friction Loss - This is the energy loss due to pipe roughness. It depends on the GPM, pipe diameter and on Mannings "n" coefficient. It is the friction loss from the current station to the previous station.

HGL - Represents the hydraulic grade line at any location under the specified flow conditions. If the pipe elevation is greater than the HGL, then the system doesn't have enough pressure to get the water to that point or beyond. If this happens "no flow" will appear in the table. Even if the table shows flow beyond that point there will be none. Try putting in larger pipe size This will decrease the friction loss and will give you a higher HGL.

Section psi - This is the pressure in the pipe at a particular point when the tank is at the specified pressure.

The HGL and Section psi have been provided for both the high and low settings on the pressure tank. You may not have enough pressure to deliver water at the low setting.

High Static - This is the pressure in the pipeline when there is no flow in the pipeline and the pressure tank is at the maximum setting. This is the maximum pressure the pipeline will have to withstand. Check this column to determine the minimum pressure rating for the pipe.

Design Pressure for Pipeline - This is the pressure that the given section of pipe has to be designed for. It includes a safety factor for waterhammer.

	PVC			SDR - PVC					PE
Size	SCH 40	SCH 80	SCH120	SDR 32.5	SDR 26	SDR 21	SDR 17	SDR 13.5	
3/4"	0.82	0.74	0.71	NA	NA	0.93	0.93	0.89	0.82
1"	1.05	0.96	0.92	NA	1.2	1.19	1.16	1.12	1.05
1 1/4"	1.38	1.28	1.23	1.54	1.54	1.5	1.46	1.41	1.38
1 1/2"	1.61	1.5	1.45	1.78	1.75	1.72	1.68	1.62	1.61
2"	2.07	1.94	1.88	2.23	2.19	2.15	2.1	2.02	2.07
2 1/2"	2.47	2.32	2.28	2.7	2.66	2.6	2.54	2.45	2.47

Plastic Pipe Inside Diameters

Note:
For further details see appropriate ASTM or AWWA Standards. Information is also included in Missouri Livestock Watering Systems Handbook, Chapter 5.

Client: Exhibit 1 Design Tab Example   Date: 3/31/00
DSN By: CHK By: _____   Date: _____
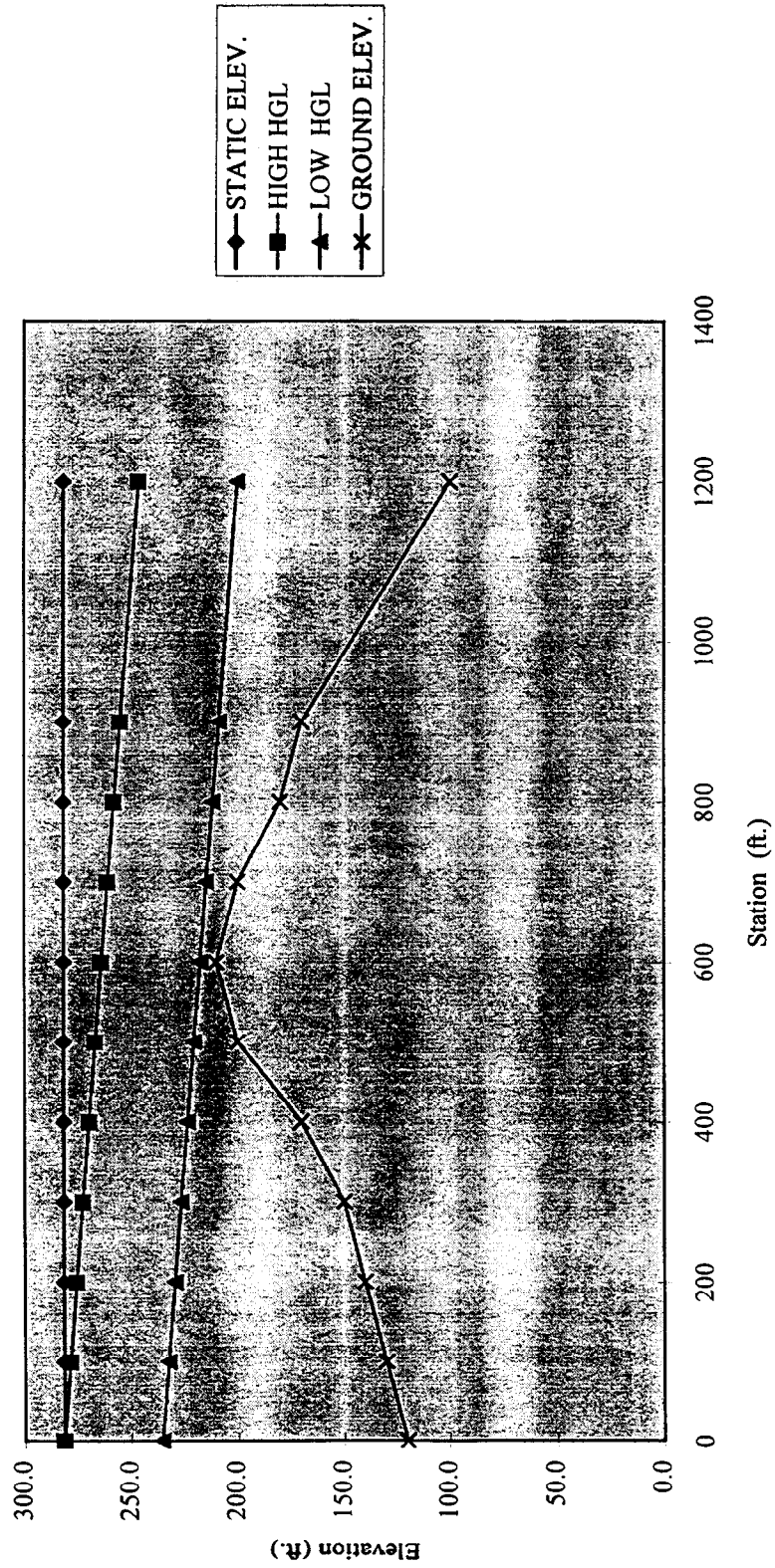Comments:

Pressure Tank elevation (ft.)	120
High pressure from tank (psi)	70
Low pressure from tank (psi)	50
Mannings "n"	0.009

Section Number	Station (ft.)	Outlet (gpm)	Total (gpm)	Ground Elev. (ft.)	Pipe ID (in.)	Design Pressure for Pipeline (psi)	Velocity (fps)
(press. tank)	0	No outlet	6	120	NA	100.0	
2	100	0	6	130	1.05	92.0	2.2
3	200	0	6	140	1.05	84.0	2.2
4	300	0	6	150	1.05	75.9	2.2
5	400	0	6	170	1.05	61.7	2.2
6	500	0	6	200	1.05	41.3	2.2
7	600	0	6	210	1.05	33.3	2.2
8	700	0	6	200	1.05	37.7	2.2
9	800	0	6	180	1.05	48.2	2.2
10	900	0	6	170	1.05	52.6	2.2
11	1200	6	6	100	1.05	90.4	2.2
12	0						
13	0						
14	0						
15	0						

Section Number	Friction Loss (ft.)	High HGL (ft.)	High Section (psi)	Low HGL (ft.)	Low Section (psi)	High Static (psi)
1	None	281.5	70.0	235.4	50.0	70.0
2	2.95	278.6	64.4	232.4	44.4	65.7
3	2.95	275.6	58.8	229.5	38.8	61.3
4	2.95	272.7	53.2	226.5	33.2	57.0
5	2.95	269.7	43.2	223.6	23.2	48.3
6	2.95	266.8	28.9	220.6	8.9	35.3
7	2.95	263.8	23.3	217.7	3.3	31.0
8	2.95	260.9	26.4	214.7	6.4	35.3
9	2.95	257.9	33.8	211.8	13.8	44.0
10	2.95	254.9	36.8	208.8	16.8	48.3
11	8.86	246.1	63.3	199.9	43.3	78.7
12						
13						
14						
15						

Pipeline HGL

Legend:
- STATIC ELEV.
- HIGH HGL
- LOW HGL
- GROUND ELEV.

X-axis: Station (ft.)
Y-axis: Elevation (ft.)

Client: Exhibit 2 Design Tab Example   Date: 3/31/00
DSN By: